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THE POSITION OF THE NEW ENGLAND PENEPLANE IN THE WHITE MOUNTAIN REGION*

By A. K. LOBECK

[With separate diagram, Pl. II, facing page 56.]

The extensive upland which covers much of New England is interrupted in its northern portions and especially in those most distant from the sea by several mountain groups. Chief among these are the White Mountains, which culminate in the splendid series of peaks and crests known as the Presidential Range, whose highest member, Mount Washington, lifts its summit a mile above the valleys at its base. From marginal peaks, as for instance Mount Kearsarge, near North Conway, a magnificent outlook to the east and south over the broad upland may be obtained, and so open is the view that it is even possible to see sailing vessels along the coast sixty miles away. Whether the White Mountains represent the northern part of the New England upland, strongly uplifted and dissected, or whether they are a group of monadnocks standing upon the remarkably well-developed peneplane recognized in the upland surface, is the thesis of this article.

The New England peneplane is one of the best-known topographic features of Massachusetts, Rhode Island, and Connecticut, and is characteristically developed in southern New Hampshire. The area as a whole has been made classic by the work of Professor Davis, and the reader is referred to his ''Physical Geography of Southern New England'' for a vivid picture of the character of the country.[1] Among the monadnocks in this part of New England he mentions Mount Monadnock in New Hampshire, Mount Wachusett and Blue Hill in Massachusetts. Professor Davis emphasizes the fact that ''there are not many monadnocks in southern New England: the rolling upland is seldom dominated by any strong summits . . . . . but on passing northward into Vermont, New Hampshire, and Maine, monadnocks are common. The White Mountains seem to be only a cluster of unconsumed remnants . . . . . but, in spite of the nearness of these northern states, they have not been explored with the upland peneplain and the monadnocks in mind. No definite statement can at present be given as to the altitude of the upland in northern New England, or as to the degree of perfection that it attained. The region invites careful investigation.'' The same view was later expressed by Professor Davis as follows: ''The White Mountains have been, in my mind, tentatively classed as a group of monadnocks; they do not, as far as I have seen them in brief excursions, stand upon any distinct basement comparable to that of the uplands of New England further south . . . . . Its [northern New England] ruggedness is generally so great that it is quite possible that the peneplain explanation does not apply to the greater part of the area. Little wonder that an observer whose attention is given to this mountainous district, under the impression that its mountain tops represent the remnants of a peneplain, should come to discredit such an explanation.'' [2]

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* My thanks are due to Professor D. W. Johnson of Columbia University, whose course in the Physiography of the Eastern United States first created an interest in this problem.

[1] National Geographic Monographs, American Book Co., New York, 1896, pp. 269-304; references on pp. 282-283.

The monadnock character of the White Mountains has also been pointed out by Doctor Bowman, who says[3] in addition that the ''plateau remnants that lie about their bases are from 1,000 to 2,000 feet elevation above the sea.'' He remarks[4] that ''The whole of Maine southeastward of the White Mountains axis is a gently inclined upland sloping with marked regularity toward the sea,'' and gives a section of local area which shows the remarkable degree of base-leveling that had been reached. While portraying one general character of the peneplane the section is, however, too far from the mountains and too close to the sea to serve as evidence of that relationship between the mountains and the upland which forms the theme of this paper.

On the other hand, Professor Goldthwait, in one of his interesting articles on the White Mountains published two years ago, made the rather striking suggestion that the flat-topped spurs near the summits of the range at an altitude of about 5,000 feet may represent remnants of an old graded upland and that quite possibly this upland is the northern extension of the New England peneplane.[5] Not only does he suggest ''that the subdued cones of Washington, Jefferson, Adams, and the other summits of the range are low monadnocks surmounting a peneplain whose only surviving fragments, in this district, are the upland lawns and Alpine pastures that lie along the crest of the range,'' but he points out the possibility that this peneplane is the New England upland so well known to the south.

A study of the region has led the writer to conclude that the New England upland is not to be recognized in the higher levels of the Presidential Range but that it abuts abruptly against the foot of the mountains. The flat-topped spurs described by Goldthwait are far above the upland level and cannot be correlated with it. The evidence leading to this conclusion was derived from a study of maps and from work in the field.

Map Evidence: Projected Profiles. The evidence available from the maps was secured by preparing a series of profiles in such a manner that the New England peneplane might be traced from the places where it is well known and easily recognizable to the White Mountain region, where its position is in doubt. The maps suitable for this purpose are (1) the contour maps in Hitchcock's atlas of New Hampshire[6] and (2) the topographic sheets of the U. S. Geological Survey covering the White Mountains and the contiguous territory of western Maine.

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[2] W. M. Davis: The Peneplain, *Amer. Geologist*, Vol. 23, 1899, pp. 207-239; references on pp. 209-210.

[3] Isaiah Bowman: Forest Physiography, New York, 1911, p. 645.

[4] *Ibid.*, p. 646.

[5] J. W. Goldthwait: Remnants of an Old Graded Upland on the Presidential Range of the White Mountains, *Amer. Journ. of Sci.*, Vol. 37, 1914, pp. 451-463; reference on p. 453.

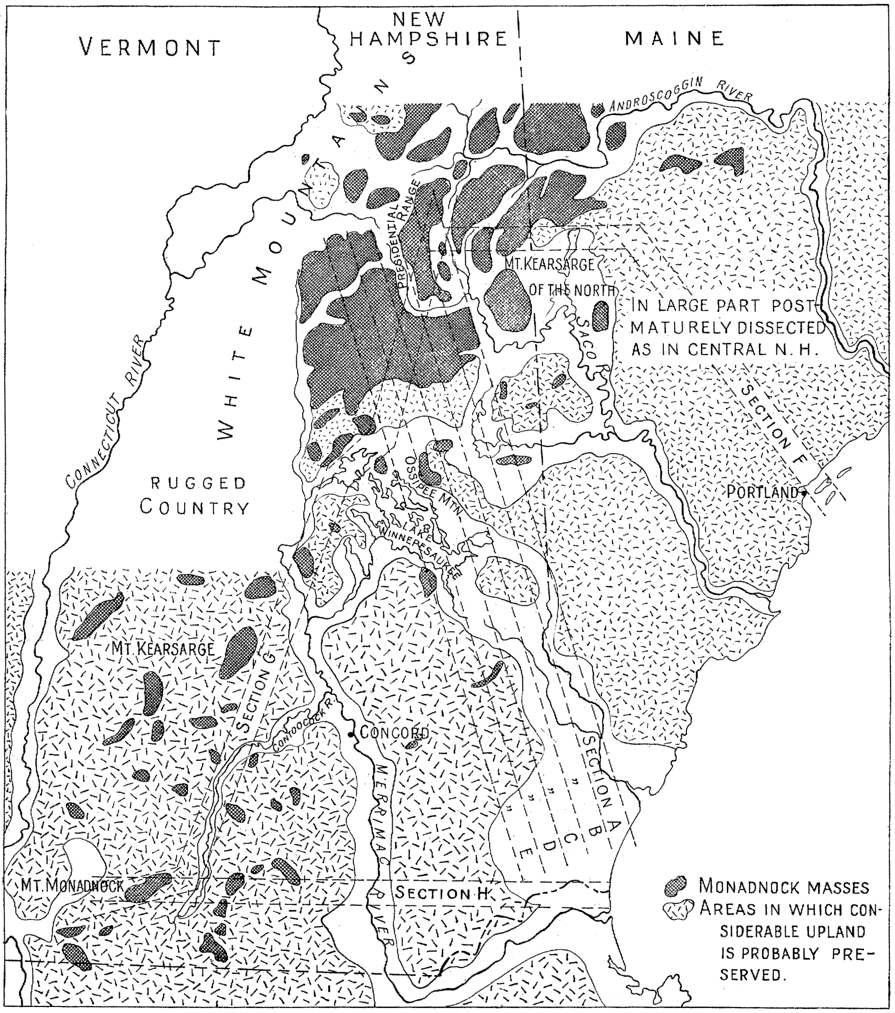

FIG. 1—Diagrammatic sketch map of New Hampshire and western Maine showing monadnock masses and approximate distribution of the New England peneplane. Scale, 1:1,800,000. The position of the profiles of Figures 2 to 5 is indicated.

The topography of belts of country three miles wide was so projected that any given point on the profile always represents the highest point in the belt opposite such point in the profile. Such a profile is exactly that which would be obtained by isolating this belt of country and then looking at it from the side so that only the highest points form the line of profile. The result is an impression strikingly similar to that which one would get by looking at the country itself.

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[6] C. H. Hitchcock: Atlas Accompanying the Report on the Geology of New Hampshire, Julius Bien, New York, 1878.

In choosing the width of belt to be projected for the purpose of revealing the existence of a badly dissected and monadnock-crowned upland, it is desirable to make the belt sufficiently narrow so that it will not encounter too many monadnocks and yet wide enough to span most of the valleys which happen to run parallel with it. If too narrow it approaches an ordinary profile and is unduly irregular because of the numerous valleys. If too wide it is also irregular, but this time because it covers so much country as to give a sky-line made up almost entirely of monadnock profiles.

The difference between this method of constructing profiles and that used by Professor Barrell[7] in his work on the supposed marine benches of Connecticut and Massachusetts is a minor one and depends mainly upon the information desired. In the method here used the tops of only those hills which form the sky line are projected. In that used by Professor Barrell the outlines of all hills in the foreground are also projected in order to reveal remnants of planes at lower levels.

A strip of country fifteen miles wide extending from the summits of the White Mountains to the sea was selected and subdivided into five parallel belts, each three miles wide. For each belt a projected profile was drawn on the basis of the contours shown in Hitchcock's atlas of New Hampshire. The position of this strip of country is shown in the sketch map, Figure 1, with the several belts marked A, B, C, D, E; and the series of projected profiles superimposed upon each other is shown in Figure 2. Each one of the profiles indicates that the New England upland in central New Hampshire ends abruptly at the base of the mountains at an altitude of 1,000 to 1,100 feet above sea level. The immediate coastal portion has been largely dissected or removed by the Exeter River and the tributaries of the Piscataqua and Merrimac Rivers. The position of Boott Spur, one of the flat-topped ''remnants'' at an altitude of 5,000 feet near the crest of the range, is also shown. It seems difficult to believe that this spur can in any way represent a part of the New England peneplane, which is so distinctly preserved at a much lower level. Several of the profiles pass through prominent monadnocks, as for example Ossipee Mountain, and some traverse pronounced lowlands, notably that now occupied by Lake Winnepesaukee.

A projected profile drawn from Mount Washington through southwestern Maine shows quite the same relation between the mountains and

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[7] Joseph Barrell: Piedmont Terraces of the Northern Appalachians and Their Mode of Origin (abstract), *Bull. Geol. Soc. of Amer.*, Vol. 24, 1913, pp. 688-670; reference on p. 689.

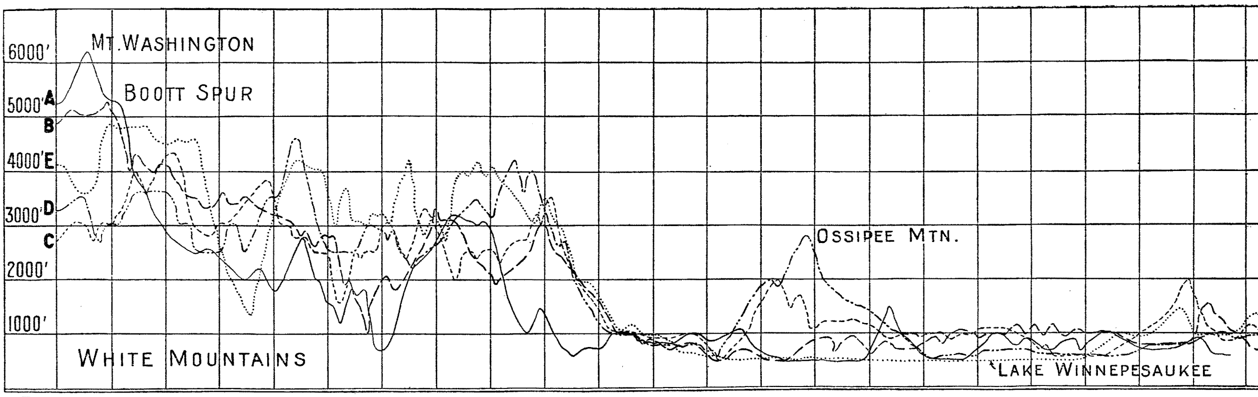
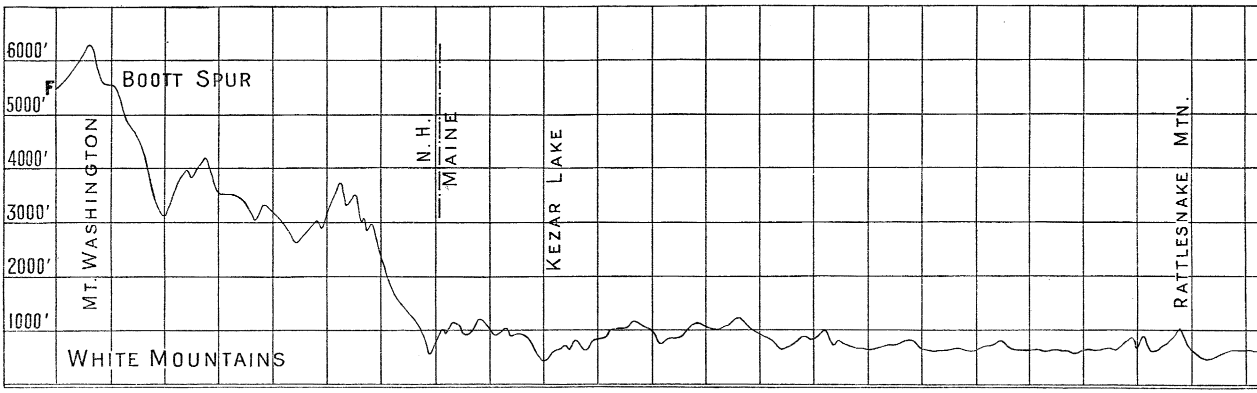


FIG. 2



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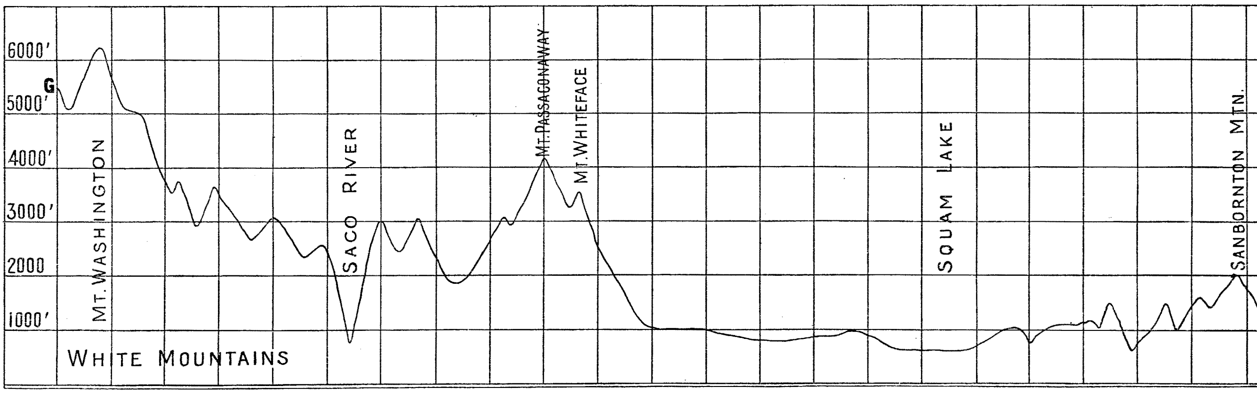

FIG. 4

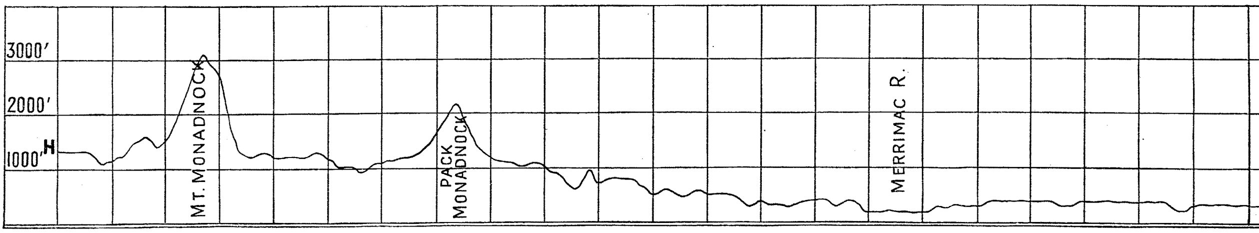

FIG. 5

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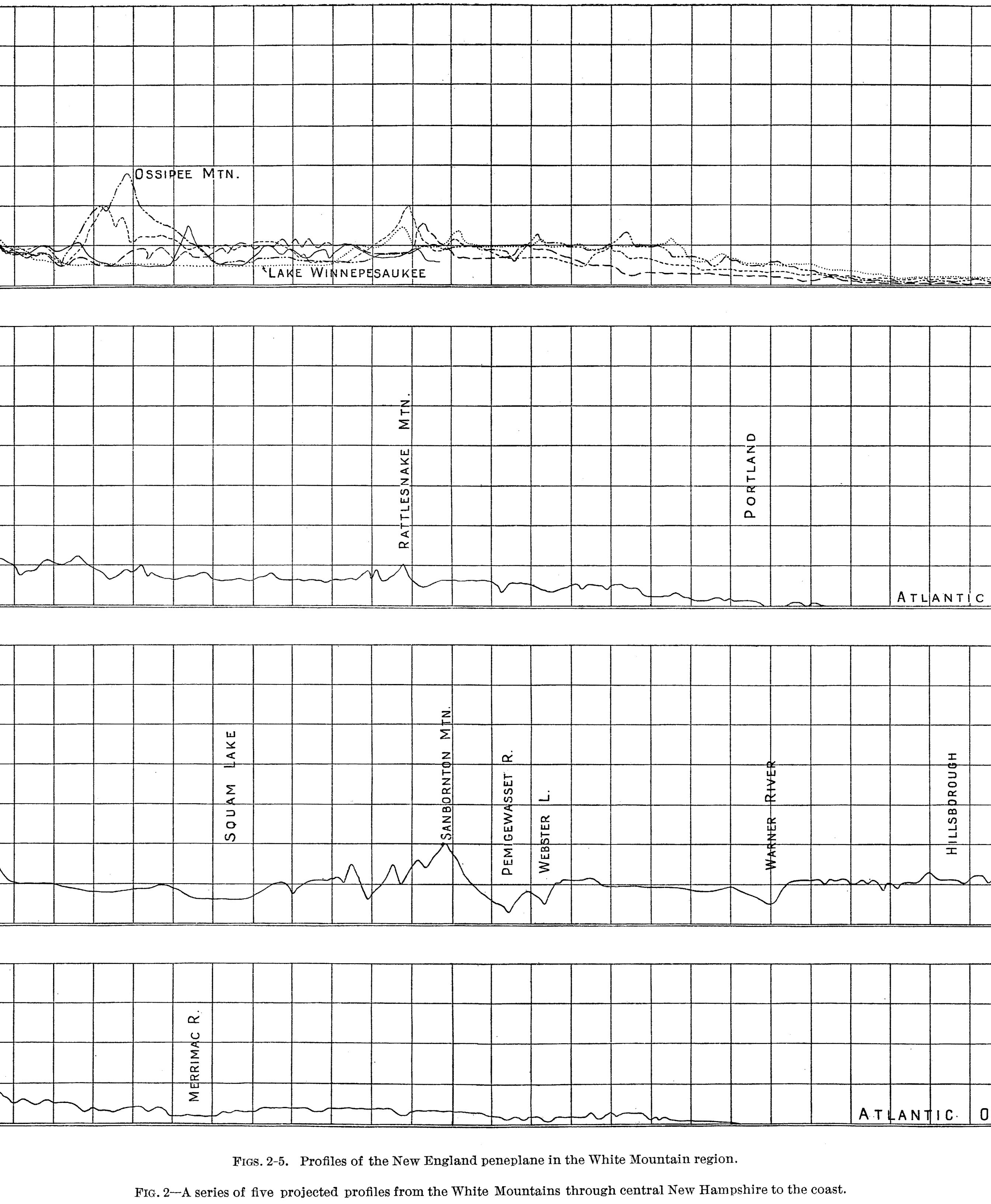
FIG. 5—Projected profile passing through Mount Mon



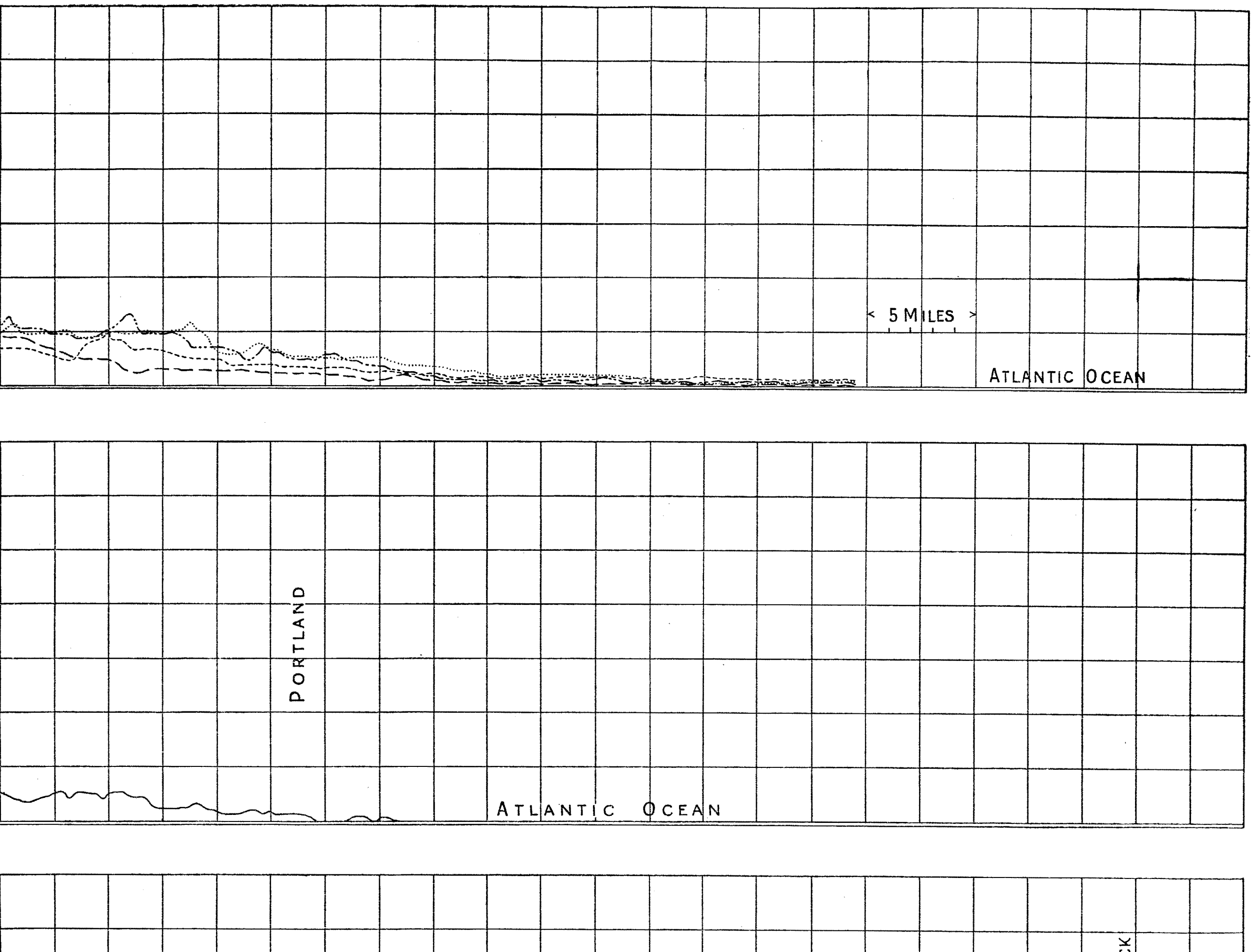
FIGS. 2-5. Profiles of the New England peneplane in the White Mountain region.

FIG. 2—A series of five projected profiles from the White Mountains through central New Hampshire to the coast.

FIG. 3—Projected profile from the White Mountains to the sea, passing through western Maine.

FIG. 4—Projected profile passing through Mount Monadnock and the White Mountains.

FIG. 5—Projected profile passing through Mount Monadnock to the coast.



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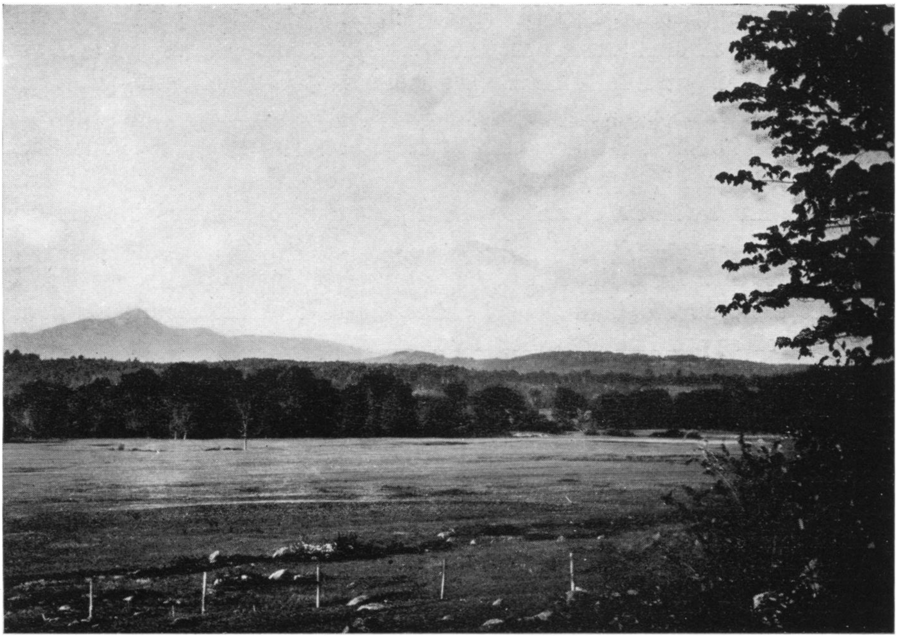

FIG. 6.

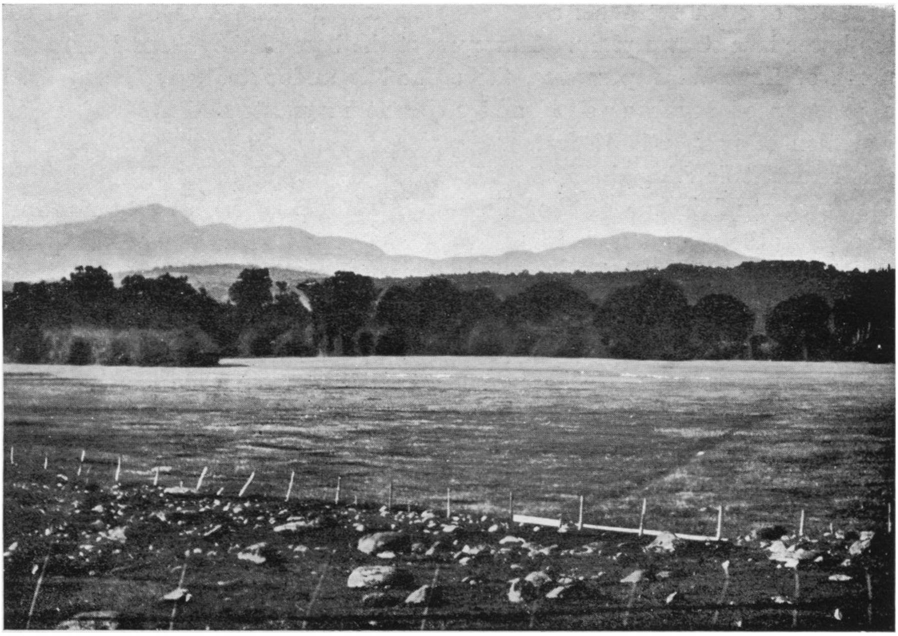

FIG. 7.

FIG. 6—The New England peneplane at the base of the White Mountains north of Ossipee Mountain.

FIG. 7—Similar to Figure 6 in showing the helflike remnant of the New England peneplane flanking the White Mountains north of Lake Winnepesaukee.

the peneplane (Section F, Fig. 3). A similar projected profile covering a belt passing through Mount Monadnock and Mount Washington is shown in Section G, Figure 4. This section shows very distinctly the peneplane as characteristically developed around Mount Monadnock and proves its continuation northward until abruptly terminated at the White Mountains. Section H, Figure 5, a projected profile drawn east from Mount Monadnock to the sea, illustrates the character of the peneplane in southern New Hampshire.

The evidence from these sections is quite conclusive and seems clearly to place the New England peneplane at the base of the mountains at an elevation of approximately 1,000 feet.

Field Evidence. Field study shows that it is possible to trace the upland from its well-recognized position at the base of Mount Monadnock, where it stands at an elevation of about 1,100 feet, northeast along Contoocock River to near Concord, where its altitude is 800 feet. North of this point it rises again to about 1,000 feet near Lake Winnepesaukee. In central and eastern New Hampshire it is post-maturely dissected and the broad lowlands are occupied by lakes and alluvial plains which lie 400 to 500 feet below the peneplane level. In the Lake Winnepesaukee region it is, as a matter of fact, difficult to trace the upland for the reason that it is preserved only as fragments and the region is complicated by the presence of such residuals as Ossipee Mountain which rise directly from the lower lake-strewn plain. However, at the base of the White Mountains north of Lake Winnepesaukee, the upland is undoubtedly represented by a pronounced bench or shelf and adjacent remnants which stand at an elevation of nearly 1,100 feet. The photographs, Figures 6 and 7, show this remnant flanking the mountains which are visible in the distance. In the foreground is one of the alluvium-filled valleys cut several hundred feet below the peneplane level. These views were taken looking north near the little town of South Tamworth at the north end of Ossipee Mountain.

A critical point in the field for observation is Mount Kearsarge of the North, which stands almost at the southern edge of the mountains near North Conway. From this position toward the northwest the peaks and spurs of the Presidential Range are distinctly visible. To the south Ossipee Mountain stands out with the broken peneplane stretching away to the southeast. Just north of Ossipee Mountain is the lowland which separates it from the White Mountains. Along the base of the mountains and projecting into this lowland may be seen the shelflike remnant before mentioned. In the mountains there is no more suggestion of the peneplane. It is practically impossible from this viewpoint to conceive how the level upland terminating abruptly at the base of the mountains can also be represented by the spurs near the crest of the range at some 4,000 feet greater elevation. To the east there is a similar contrast between the remarkably well-developed upland of western Maine and the steep slopes of the mountains.

Conclusion. An attempt is made in the sketch map, Figure 1, to indicate the areas in which remnants of the peneplane are now preserved. The map does not pretend to be precise in detail, but the comparative extent of dissected upland, monadnock residuals, and broad lowlands is suggested and may convey to the mind a useful picture.

We can describe the region of central and southern New Hampshire as a post-maturely dissected peneplane surmounted by numerous monadnocks, especially away from the stream courses. The broad valley floors are covered with alluvium or, where blocked by glacial drift, form shallow though sometimes extensive lake basins, as that of Lake Winnepesaukee. The peneplane rises gradually from the coast and ends abruptly at the foot of the White Mountains, where its elevation is about 1,000 feet. In western Maine the peneplane is remarkably well preserved and appears to be less dissected than in New Hampshire. The conclusions derived from both field and map study are in strict accord, and one is constrained to believe that the spurs near the mountain crests have no relation to the upland so well developed to the east and to the south.

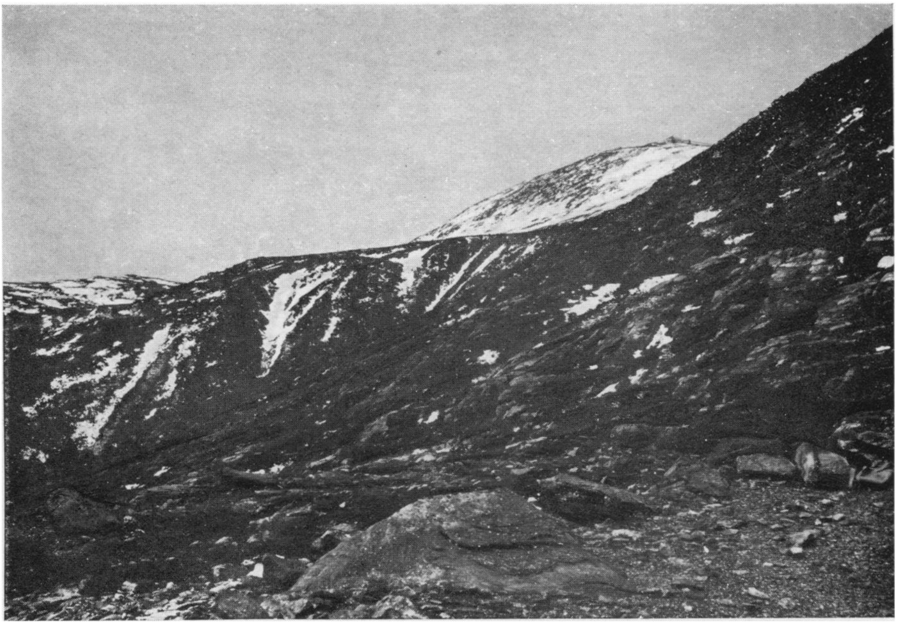

FIG. 8—Boott Spur, a remnant of the upland bench or terrace projecting from the side of Mount Washington.

The fact that these spurs may have another meaning has not been overlooked by Professor Goldthwait. He gives as suggestions[8] "that the flatness of the crown of the range is due chiefly to the more rapid reduction of the slopes above the tree line, where frost action and the movement of rock waste are more vigorous than in the forest,'' or ''that one might look for some structural control of the upland flats—some dominant system of joints, or some very extensive development of schistosity in plains near the horizontal.'' And he mentions the possibility ''that the flattening out of these graded slopes, in their descent, near the 4,000-foot contour is not as real as it appears to be; that the original well-graded slopes of the range have been so deeply and so widely scooped away by local glaciers and the resultant spurs have been so much worn, especially at low altitudes, by glaciation during the subsequent regional glaciation that the effect is a false appearance of an uplifted and extensively dissected cluster of low monadnocks.''

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[8] J. W. Goldthwait, *op. cit.*, p. 462.

Observations by Professor D. W. Johnson on the north end of the range lead him to the opinion that the great discordance in the heights of the flat-topped spurs, amounting in cases to more than a thousand feet, and the fact that several of the supposed upland remnants have a high angle of slope, militate against any theory of their origin which would consider them parts of a former peneplane. My own brief study inclines me to believe that the spurs are not so pronounced a feature as to demand any special explanation.